

WE CLAIM:

1. A photovoltaic device having a multiple quantum well portion with alternating tensile strained layers and compressively strained layers, said tensile strained layers
5 and said compressively strained layers having compositions such that a period of one tensile strained layer and one compressively strained layer exerts substantially no shear force on a neighbouring structure.

2. A photovoltaic device as claimed in claim 1, wherein said neighbouring
10 structure is one of:
a further period of one tensile strained layer and one compressively strained layer;
a layer of arbitrary doping having the same lattice constant as a substrate; and
a substrate.

3. A photovoltaic device as claimed in claim 1, being a crystalline photovoltaic
15 device grown upon a substrate with a substrate lattice constant.

4. A photovoltaic device as claimed in claim 3, wherein at least one of said
tensile strained layers or said compressively strained layers is a quantum well having
20 a Group III/V semiconductor composition with a bandgap lower than if said quantum well had a lattice constant equal to said substrate lattice constant.

5. A photovoltaic device as claimed in claim 3, wherein at least one of said
tensile strained layers or said compressively strained layers is a barrier having a
25 Group III/V semiconductor composition with a bandgap higher than if said barrier had a lattice constant equal to said substrate lattice constant.

6. A photovoltaic device as claimed in claim 1, wherein said multiple quantum
well portion is formed of alternating quantum well layers and barrier layers having a
30 Group III/V semiconductor composition, wherein a period of one quantum well layer and one quantum barrier layer contains at least four different elements and has an average lattice constant substantially matching a neighbouring structure lattice constant.

7. A photovoltaic device as claimed in claim 4, wherein said substrate is InP and said compressively strained layer is $\text{In}_x\text{Ga}_{1-x}\text{As}$, where $x>0.53$.

8. A photovoltaic device as claimed in claim 5, wherein said substrate is InP and said tensile strained layer is $\text{In}_x\text{Ga}_{1-x}\text{As}_{1-y}\text{P}_y$, where $y>0$.

9. A photovoltaic device as claimed in claim 8, wherein $y=1$ such that said tensile strained layer is GaInP.

10. A photovoltaic device as claimed in claim 3, wherein said substrate is InP and said multiple quantum well portion is formed of layers of $\text{Al}_x\text{Ga}_{1-x}\text{As}_y\text{Sb}_{1-y}$, where $0\leq x\leq 1$ and $0\leq y\leq 1$.

11. A photovoltaic device as claimed in claim 3, wherein said substrate is GaSb and said multiple quantum well portion is formed of layers of $\text{In}_x\text{Ga}_{1-x}\text{As}_y\text{Sb}_{1-y}$, where $0\leq x\leq 1$ and $0\leq y\leq 1$.

12. A photovoltaic device as claimed in claim 3, wherein said substrate is GaAs.

13. A photovoltaic device as claimed in claim 12, wherein said multiple quantum well portion is formed of layers of $\text{In}_x\text{Ga}_{1-x}\text{As}_y\text{P}_{1-y}$, where $0\leq x\leq 1$ and $0\leq y\leq 1$.

14. A photovoltaic device as claimed in claim 1, wherein said multiple quantum well portion is formed upon a virtual substrate composed of a strain relaxed buffer layer having a virtual substrate lattice constant different from a substrate lattice constant of an underlying substrate.

15. A photovoltaic device as claimed in claim 14, wherein said virtual substrate is $\text{InP}_{1-y}\text{As}_y$, where $0<y<1$, and said substrate is InP.

16. A photovoltaic device as claimed in claim 1, wherein said photovoltaic device is a thermophotovoltaic device.

17. A photovoltaic device as claimed in claim 1, wherein said quantum wells have a bandgap substantially equal to or less than 0.73eV

18. A photovoltaic device having a multiple well quantum portion formed upon a virtual substrate having a virtual substrate lattice constant different than a substrate lattice constant of an underlying substrate, wherein said virtual substrate is $\text{InP}_{1-x}\text{As}_x$, where $0 < x < 1$, and said substrate is InP.

19. A photovoltaic device as claimed in claim 18, wherein said multiple quantum well portion is formed with alternating tensile strained layers and compressively strained layers, said tensile strained layers and said compressively strained layers having compositions such that a period of one tensile strained layer and one compressively strained layer exerts substantially no shear force on a neighbouring structure.

20. A photovoltaic device as claimed in claim 19, wherein said neighbouring structure is one of:
a further period of one tensile strained layer and one compressively strained layer;
a layer of arbitrary doping having the same lattice constant as said virtual substrate;
and
said virtual substrate.

21. A photovoltaic device as claimed in claim 18, wherein at least one of said tensile strained layers or said compressively strained layers is a quantum well having a Group III/V semiconductor composition with a bandgap lower than if said quantum well had a lattice constant equal to said substrate lattice constant.

22. A photovoltaic device as claimed in claim 18, wherein at least one of said tensile strained layers or said compressively strained layers is a barrier having a Group III/V semiconductor composition with a bandgap higher than if said barrier had a lattice constant equal to said substrate lattice constant.

23. A photovoltaic device as claimed in claim 18, wherein said multiple quantum well portion is formed of alternating quantum well layers and barrier layers having a

Group III/V semiconductor composition, wherein a period of one quantum well layer and one quantum barrier layer contains at least four different elements and has an average lattice constant substantially matching a neighbouring structure lattice constant.

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24. A photovoltaic device as claimed in claim 21, wherein said substrate is InP and said compressively strained layer is $\text{In}_x\text{Ga}_{1-x}\text{As}$, where x is larger than z of $\text{In}_z\text{Ga}_{1-z}\text{As}$ which is lattice-matched to the virtual substrate.

10 25. A photovoltaic device as claimed in claim 23, wherein said substrate is InP and said tensile strained layer is $\text{In}_x\text{Ga}_{1-x}\text{As}_{1-y}\text{P}_y$, where $y>0$.

15 26. A photovoltaic device as claimed in claim 25, wherein $y=1$ such that said tensile strained layer is GaInP or wherein $x=1$ such that said tensile strained layer is InAsP

20 27. A photovoltaic device as claimed in claim 18, wherein said substrate is InP and said multiple quantum well portion is formed of layers of $\text{Al}_x\text{Ga}_{1-x}\text{As}_y\text{Sb}_{1-y}$, where $0\leq x\leq 1$ and $0\leq y\leq 1$.

28. A photovoltaic device as claimed in claim 18, wherein said substrate is GaSb and said multiple quantum well portion is formed of layers of $\text{In}_x\text{Ga}_{1-x}\text{As}_y\text{Sb}_{1-y}$, where $0\leq x\leq 1$ and $0\leq y\leq 1$.

25 29. A photovoltaic device as claimed in claim 18, wherein said substrate is GaAs.

30. A photovoltaic device as claimed in claim 29, wherein said multiple quantum well portion is formed of layers of $\text{In}_x\text{Ga}_{1-x}\text{As}_y\text{P}_{1-y}$, where $0\leq x\leq 1$ and $0\leq y\leq 1$.

30 31. A photovoltaic device as claimed in claim 18, wherein said photovoltaic device is a thermophotovoltaic device.

32. A photovoltaic device as claimed in claim 18, wherein said quantum wells have a bandgap substantially equal to or less than 0.73eV

33. A photovoltaic device having a multiple quantum well portion formed of strained alternating quantum well layers of $\text{In}_x\text{Ga}_{1-x}\text{As}$, where $x > 0.53$, and barrier layers of $\text{Ga}_y\text{In}_{1-y}\text{P}$, where $y > 0$.

34. A photovoltaic device as claimed in claim 33, wherein said multiple quantum well portion is formed with alternating tensile strained layers and compressively strained layers, said tensile strained layers and said compressively strained layers having compositions such that a period of one tensile strained layer and one compressively strained layer exerts substantially no shear force on a neighbouring structure.

35. A photovoltaic device as claimed in claim 34, wherein said neighbouring structure is one of:
a further period of one tensile strained layer and one compressively strained layer;
a layer of arbitrary doping having the same lattice constant as a substrate; and
a substrate.

36. A photovoltaic device as claimed in claim 33, being a crystalline photovoltaic device grown upon a substrate layer with a substrate lattice constant.

37. A photovoltaic device as claimed in claim 36, wherein said substrate is InP.

38. A photovoltaic device as claimed in claim 33, wherein said multiple quantum well portion is formed upon a virtual substrate composed of a strain relaxed buffer layer having a virtual substrate lattice constant different from a substrate lattice constant of an underlying substrate.

39. A photovoltaic device as claimed in claim 38, wherein said virtual substrate is $\text{InP}_{1-y}\text{As}_y$, where $0 < y < 1$, and said substrate is InP.

40. A photovoltaic device as claimed in claim 33, wherein said photovoltaic device is a thermophotovoltaic device.

41. A photovoltaic device as claimed in claim 33, wherein said quantum wells
5 have a bandgap substantially equal to or less than 0.73eV.